the light proceeds in slightly different directions based on wavelengths, for example, illustrated as rays λ**1**, λ**2**, and λ**3**. Detailed structures of the split metasurface **511** will be described later with reference to FIGS. **13** and **14**. After the split metasurface **511** splits the light into the first polarization light **810** and the second polarization light **812**, the split metasurface **511** may resolve the first polarization light **810** based on each wavelength to transmit the resolved first polarization light **810** to the first focusing metasurface **512**, and may resolve the second polarization light **812** based on each wavelength to transmit the resolved second polarization light **812** to the second focusing metasurface **513**. For example, the first polarization light **810** may be TE mode light, and the second polarization light **812** may be TM mode light, or vice versa.

[0108] The first focusing metasurface **512** and the second focusing metasurface **513** have substantially the same functionality as the focusing metasurface **111** of FIG. **1**, and thus, detailed descriptions of the first focusing metasurface **512** and the second focusing metasurface **513** will be omitted. The first focusing metasurface **512** may focus the first polarization light **810** and transmit the focused first polarization light **810** to the first sensor **521**. The second focusing metasurface **513** may focus the second polarization light **812** and transmit the focused second polarization light **812** to the second sensor **522**.

[0109] The first sensor **521** and the second sensor **522** are substantially the same as the sensor **120** of FIG. **1**, and thus, detailed descriptions of the first sensor **521** and the second sensor **522** will be omitted.

[0110] The spectrometer **500** may additionally resolve light elements based on polarization, and may have a sufficiently long optical path, with respect to a volume of the spectrometer **500**, to thereby increase spectrum efficiency.

[0111] FIG. **13** is a view of a split metasurface **511** according to an exemplary embodiment. FIG. **14** is a view of a nanostructure pattern of the split metasurface **511** of FIG. **13**.

[0112] Referring to FIGS. **13** and **14**, the split metasurface **511** may include a pattern including a plurality of nanostructures arranged such that diameters of the plurality of nanostructures increase and then decrease in an x axis direction, and the pattern may be cyclically repeated in the x axis direction and a y axis direction. Each of the diameters of the plurality of nanostructures in the x axis direction and the diameters of the plurality of nanostructures in the y axis direction may increase or decrease, and each of the plurality of nanostructures may control light in different polarization states due to a diameter difference. Thus, the light is reflected, diffracted, and emitted in opposite directions. For example, when the diameters or dimensions of cross-sections of the nanostructures in the y axis direction are k_0, k_1, k_2, k_3, k_4, k_5, k_6, k_7, and k_8, the diameters or dimensions k_0 to k_5 may gradually increase, and the diameters or dimensions k_6 to k_8 may gradually decrease.

[0113] The split metasurface **511** may reflect light by splitting the light into first polarization light **810** and second polarization light **812** based on polarization. For example, the first polarization light **810** may be reflected in a +x axis direction and the second polarization light **812** may be reflected in a −x axis direction.

[0114] The spectrometers **100** to **500** according to an exemplary embodiment may include the metasurface which may replace various optical elements, such as a convex lens, a concave lens, a prism, a beam polarizer, etc. The metasurface may include a plurality of nanostructures that are two-dimensionally arranged.

[0115] The spectrometers **100** to **500** according to an exemplary embodiment include the metasurface that is relatively smaller than the optical elements, and thus, the spectrometers **100** to **500** may have reduced volumes.

[0116] For example, the spectrometers **100** to **500** according to an exemplary embodiment may have a length of the optical path, which is relatively great with respect to the volumes of the spectrometers **100** to **500**, to thus have an improved spectrum performance.

[0117] The foregoing exemplary embodiments and advantages are merely exemplary and are not to be construed as limiting. The present teaching can be readily applied to other types of apparatuses. Also, the description of the exemplary embodiments is intended to be illustrative, and not to limit the scope of the claims, and many alternatives, modifications, and variations will be apparent to those skilled in the art.

What is claimed is:

1. A spectrometer comprising:

a transparent substrate comprising a first surface and a second surface facing each other;

a slit provided on the first surface and through which light is incident onto the transparent substrate;

a spectrum optical system comprising at least one metasurface comprising a plurality of nanostructures that are two-dimensionally arranged, wherein the at least one metasurface comprises a focusing metasurface which includes first nanostructures of the plurality of nanostructures, and is configured to reflect and focus the light incident thereon through the slit, at different angles based on respective wavelengths; and

a sensor configured to receive the light from the focusing metasurface.

2. The spectrometer of claim **1**, further comprising a block layer provided at the first surface of the transparent substrate and configured to block the light from being emitted onto areas of the transparent substrate other than the slit.

3. The spectrometer of claim **1**, wherein the spectrum optical system further comprises a collimating metasurface comprising second nanostructures of the plurality of nanostructures, the second nanostructures being two-dimensionally arranged to have a collimating function.

4. The spectrometer of claim **3**, wherein the collimating metasurface is located on an optical path between the slit and the focusing metasurface.

5. The spectrometer of claim **3**, wherein the spectrum optical system further comprises a grating metasurface comprising third nanostructures of the plurality of nanostructures, the third nanostructures being two-dimensionally arranged to have a chromatic dispersion function.

6. The spectrometer of claim **5**, wherein the grating metasurface is located on an optical path between the collimating metasurface and the focusing metasurface.

7. The spectrometer of claim **5**, wherein the grating metasurface and the sensor are provided on the first surface, and

the collimating metasurface and the focusing metasurface are provided on the second surface.

8. The spectrometer of claim **6**, wherein the grating metasurface, the collimating metasurface, the focusing